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ABSTRACT

This experiment tested conjectures concerning the effects of learners' attending preferences on the establishment of auditory-visual intersensory associations in a bisensory paired associate task. Attending patterns were identified through the use of a bisensory diget-span task. On the basis of fifth and sixth grade subjects' performance during the recall portion of that task, two groups of attenders were identified on the basis of visual error rate. Performance of those groups was then compared on a bisensory paired-associate task in which half of the bisensory pairs had the visual item defined as the nominal stimulus while half of the items had the auditory member so defined. Overall, the former condition was less difficult. An ordinal interaction was found in which the low visual errors group outperformed the high visual errors group in the later trials of the visual stimulus condition. No significant differences were found in the auditory stimulus condition. Further, some evidence was found that suggests a relationship between the attending patterns and reading achievement. (Author/WR)

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Modality Preferences and Intersensory Associations in Children

Gary M. Ingersoll
Department of Educational Psychology
2805 East Tenth Street
Indiana University
Bloomington, Indiana 47401

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Preface

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INTRODUCTION

Of the basic processes theorized to be involved in the acquisition of reading skills, few have been accorded the degree of consensus that has been given to the establishment of grapheme-phoneme correspondence. Most theories of reading assume that early stages of reading acquisition are related to the learner's ability to create an associative link between a visual, or graphemic, stimulus and an auditory, or phonemic, correspondent. It is to that general area that this study is addressed. Specifically, the purpose of this research was to study the effects of differences in learner predispositions in attending to and recalling auditory or visual stimuli under bisensory presentation on the establishment of intersensory associations. An additional purpose of the study was to test the limits of generalizing from earlier research with adults (Ingersoll & Di Vesta, 1972; 1974) to similar bisensory stimulus arrangements with children.

Intersensory Auditory-Visual Associations

It has been contended that beginning reading is primarily a process of equating an auditory, or phonemic, stimulus with a visual, or graphemic, stimulus (see, for example, Gibson, 1965, 1970; Jones, 1972; Venesky, 1967). This integration of auditory and visual information has been described by Strang (1968) as crucial for most children in learning to read. Although learning to read has repeatedly been described as establishing visual stimulus equivalents for an auditory system, the intersensory or bisensory auditory-visual relationships implied by such a model have only recently become the subject of study. Given the assumption of an intersensory associative model of early reading, there are possible individual differences which might differentially facilitate or impede the acquisition of those associations. If, for example, the ability to establish intersensory auditory-visual associations were to be studied as a function of attending preferences or processing strategies under bisensory stimulation, differential patterns of acquisition should be found.

Gibson (1965) has argued that the development or acquisition of reading skills is composed of four overlapping stages. The research proposed herein is directed towards the development of an empirical understanding of the third stage: learning to decode graphic symbols into speech. Given the view that initial reading is related to the establishment of an equivalence of a graphic symbol to an auditory symbol, the initial acquisition of word reading

responses appears to be analogous to the paired-associate (PA) model. However, the PA model implied is of a bisensory nature. Once an intersensory auditory-visual association has been established over several pairings, the presentation of one stimulus (i.e., the visual) elicits an implicit simultaneous response of the other (i.e., the auditory) and all the responses simultaneously mediated by the meaning of that stimulus. Once an intersensory association has been established, either the visual or the auditory stimulus should be capable of eliciting appropriate semantic mediators (Smith, 1971; Smith and Holmes, 1971).

The conjecture that initial reading skills are primarily associative would imply that individual differences in attending preferences should be important factors. This hypothesis is based in part on Schulz's (1969) conclusion that any differences due to presentation modality factors are likely to affect learning during the associative phase.

Limited Capacity Processing

While Hebb (1949) and Davis (1967) provide theoretical positions that are relevant to the study of bisensory processing, the model that has had the greatest impact, through the initiation of new research in the area, has been that provided by Broadbent (1958, 1963). Fundamentally, Broadbent proposed that the human learner is limited in the rate at which he or she can process information. If that rate is superceded by overloading one processing channel (sensory modality), or if information is entered simultaneously on more than one channel, the learner will impose constraints on the flow of the information to conform to his/her limitations.

Broadbent (1954, 1956) has found that when digit-spans are presented simultaneously, independent sets to each ear, instead of recalling the digits in temporal pairs as they were presented, Ss tend to recall the digit-span from one ear and then the digit-span from the other ear. Those results were later replicated using a bisensory auditory-visual analog (Broadbent, 1956; Broadbent & Gregory, 1961), that is, when digit-spans were presented in a bisensory fashion, one set visually and an independent set auditorily, S tended to recall the set presented to one sense prior to the set presented to the other sense

Broadbent (1958) offered as an hypothesis that human information processing is limited in the rate at which information can be moved into short term storage and consequently into long term storage. Further, the rate at which

a given individual can process information is fixed. Superceding that fixed rate by external stimulation will only lead the learner to impose internal restrictions on the flow by selectively attending to the more salient, the more important, or, simply, the preferred modality. Broadbent (1963) argued further that if the rate of information flow is externally increased by multiple sources of stimulation, the learner will restrict the flow of information by processing one modality source while holding information from other modality sources in very short term sensory buffers of the type described by Sperling (1963) for visual input or by Crowder and Morton (1969) for auditory input. Information held in the sensory storage mechanisms associated with either channel is subject to immediate and rapid decay unless the information is recycled (rehearsed). Thus, when information is received simultaneously by two receptors, that set of information which is processed, or rehearsed, first, is hypothesized to be recalled more completely. The information held in storage on the other channel suffers decay while the first is rehearsed. However, it is clear from Neisser (1967) and others that the filter models of selective attention need some modification. Indeed, Peterson (1969) has shown that multiple attention is quite possible under selected conditions. The limits of processing multiple inputs may vary between tasks, over practice, and between individuals.

In an information processing model that parallels the processing patterns of digital computer, Atkinson and Shiffrin (1968) and Shiffrin and Atkinson (1969), suggest monitoring systems in which different response strategies or biases are imposed upon incoming stimuli. In addressing themselves to the problem of simultaneous inputs, Atkinson and Shiffrin (1968) note, "The first decision the subject must make concerns which sensory register to attend to. Thus, in experiments with simultaneous inputs from several sensory channels the subject can readily report information (from one channel) if so instructed in advance but his accuracy is greatly reduced if instructions are delayed until after presentation" (Atkinson & Shiffrin, 1968, p. 107). If however, no instructions are provided, the individual must impose his own preferences for monitoring information. The extent to which this is done and the stability with which it is done, should be reflected in response output.

From evidence collected in unisensory comparisons of auditory and visual presentation (Conrad & Hull, 1968; Craik, 1968; Murdock, 1966; Murdock & Walker, 1969) and from bisensory auditory-visual presentation

(Dornbush, 1968; Ingersoll & Di Vesta, 1972) there seems to be an overall difference in recall favoring the auditory modality.

Research in the area of auditory and visual presentation modalities and their effects on learning and recall have generally been directed at a comparison of the efficiency of the two modalities. For example, Schulz and his associates (Schulz, 1969; Schulz & Kasschau, 1966; Schulz & Hopkins, 1968a, 1968b) have carried out a program of research designed to compare the relative effectiveness of visual and auditory presentation on various verbal learning tasks. Schulz emphasizes the importance of such research as follows:

> It appears that detailed knowledge concerning the learning of aurally received material, comparisons of the learning of audio with visual presentation of material and the advantages and/or disadvantages of joint audio-visual presentation may have innumerable and significant potential applications in enhancing the effectiveness and efficiency of educational procedures (Schulz, 1969, p. 1).

Schulz, however, was forced to conclude that, by itself, presentation modality was not an overly potent variable. If, however, modality effects do exist, Schulz proposed that they must occur in the associative stages of learning.

Far less research has been conducted using bisensory auditory-visual presentation than research comparing the efficacy of either modality singly. Mowbray (1952, 1953) presented two connected discourse passages simultaneously, one visually and one auditorily. Following the presentation, S was questioned to determine his level of comprehension of both passages. Mowbray concluded that the auditory presentation suffered more from simultaneous presentation than did the visual. Further, Mowbray argued that the easy passages suffered more during simultaneous presentation than did the difficult passages. The latter effect may be partially the result of an artifact since level of comprehension for the difficult passages must have originally been lower, therefore, the more difficult passages would be restricted in the amount of loss possible.

Dornbush (1968) studied the effects of presentation rate and type of stimulus on bisensory memory. By varying the rate of presentation, she replicated earlier findings found with single modality auditory or visual presentation of digit-spans. That is, as the rate of presentation increased.

recall of aurally presented items was facilitated (cf. Conrad, 1957; Fraser, 1958). As the rate of presentation decreased, the recall of visually presented items was facilitated (cf. Macworth, 1962). Further, Dornbush also compared recall of numbers and letters under bisensory stimulation and found a higher level of recall for numbers. This is not overly surprising since letters would be more susceptible to acoustic errors and thus reduce overall performance (Conrad, 1964; Wicklegren, 1966). Also, the set of digits is a more frequently defined set of elements than the letters A through J, and the latter set is drawn from a much broader set of alternatives. Miller, Heise, and Lichten (1951) demonstrated that under fixed conditions of signal and noise, S was less likely to hear a word correctly if he knew it was one of a large number of alternatives than if the set of alternatives was narrow and fairly well defined.

Individual Differences and Auditory and Visual Presentation

Possible individual differences in preferences for the processing and storage of information is not a new concept. James (1892) and Galton (1883), for example, were concerned with individual differences in auditory or visual imagery. Until the early 1920's, anecdotal evidence of eidetic imagery in certain individuals was rather common in professional journals and even earlier Galton collected much data on the subject of imagery via questionnaires.

The number of studies in which individual differences have been studied under conditions of bisensory stimulation is very small. This is not overly surprising since the overall amount of bisensory research has not been sufficiently large to encourage the inclusion of individual difference variables. The additional constraint of using children as Ss limits even further the range of relevant literature. Broadbent (1956) offered anecdotal evidence to suggest different response styles might exist in the processing of bisensory stimuli. In his own research with bisensory digit-spans, Broadbent found that during recall, "there was no tendency for either sense to be universally the one delayed. In general, each subject had his own consistent preference for given the eye or the ear first." (Broadbent, 1956, pp. 147-148). This observation would be in accord with the limited capacity processing model which Broadbent proposes. However, the assumption that the first emitted response implies which modality was processed first

may not be valid. The measure of response pattern is relatively unstable under different conditions and is susceptable to perceptual set (Senf, Madsen, & Rollins, 1967). It is equally plausible that an S could adopt a strategy of rehearsing the favored channel while quickly spewing out the information presented on the non-preferred channel. Individual reports by subjects during early work by this investigator indicated that this was often the case. For instance, S might report "The auditory was easy to remember so I wrote down the visual first." In addition, there are two additional groups that appear that are not immediately congruent with that model. First, there are Ss, who when given the bisensory digit spans are able to process both rather well and display no preference. There is an additional group who also display no preference. Their performance, however, is marked by poor recall of both modalities.

Madsen, Rollins and Senf (1970) have studied the stability of response patterns to bisensory presentation across different presentation rates. It has been argued that as presentation rate decreased (pairs/sec) the ability to recall the information as pairs rather than by modality increased. Madsen et al. (1970) argued however, that when Ss were used as their own control in a within-subject's design, their consistency across conditions was much more striking than any tendency to change with treatment conditions. However, Madsen et al. did not compare individuals who consistently responded by modality to those who consistently responded by pairs on any other task.

Increasingly, evidence is accumulating to suggest that learners who have difficulty in processing intersensory stimuli also have difficulty in acquiring early reading skills. Farnham-Diggory (1972), for example, has presented evidence that young children who fail to process intersensory transitions have a greater likelihood of showing reading difficulties than those who are able to recall such transitions.

Senf (1960; Senf and Feshbach, 1970; Senf and Freud1, 1971) has repeatedly demonstrated that children with reading disabilities continually have difficulty in establishing intersensory associations. Senf (1969) compared response patterns of learning disorder children (LDC) with normal control children (NCC) and supported his argument that the LDC group was less likely to construct intersensory associations than its NCC counterpart. Senf argued that this inability would restrict the development of

reading skill. He further noted that the LDC group displayed a marked tendency to respond with the auditory channel first whereas the NCC group was fairly evenly distributed in the tendency to respond with either modality first. Following a limited capacity processing model of the type proposed by Broadbent (1958, 1963), Senf argued that the modality emitted first represented a preferred modality. However, Senf felt that response style, was a source of contamination to the treatments of concern and he therefore attempted to minimize the effect of response style, or response set, by instructing his Ss to respond in a predetermined order.

Birch and Belmont (1964, 1965) have developed a measure of auditory-visual integration ability which has been demonstrated to be related to sight vocabulary (Jones and Aaron, 1971) even when intelligence is statistically controlled. Further, intersensory transfer has been shown to have a relationship to reading achievement at early levels (Birch and Belmont, 1965; Kahn and Birch, 1968). Muehl and Kremenak (1966) and Berry (1967) have found evidence that inferior readers are less likely than better readers to be able to perform on a task of auditory-visual transfer.

In another source, this author (Ingersoll and Di Vesta, 1974) has concluded that when salient semantic cues are not available for the establishment of organized responses, the learner is forced to attend to perceptual aspects of the learning task. In introductory reading instruction, the learner must establish auditory-visual associations and such a requirement should make perceptual components of the learning task highly salient. In situations of such auditory-visual concomitants, where modalities are the salient features of the stimulus environment, attending preferences of the learner may affect information processing of new materials.

In a comparison of learners with aural and visual modality preferences, Ingersoll, & Di Vesta (1974) have demonstrated that in a bisensory PA task individuals with a modality preference[1] display differential recall patterns when a modified study-recall model is used. In that study, the learner was required to learn a list of associates as in a PA task. However, in this case, an intersensory association had to be made. One half of the pair was

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[1] In an earlier study, Ingersoll and Di Vesta foresaw the possibility that the term modality preference would have limited value. Thus, due to the expansion of the model implicit in this study, the term attending preference is used

Presented visually while the associate was presented auditorily. The learner's task was to learn as many of the pairs and/or as much of the complete list as he could within a limited number of trials. A modified study-test procedure was used. Unlike the results of short-term memory tasks (Ingersoll and Di Vesta, 1972; 1974) the data from the bisensory PA task revealed no differences between aural attenders and visual attenders on the recall of auditory and visual stimuli. However, large differences were found in the ability to associate the items as pairs. Further, that difference clearly favored aural attenders.

Since overall visual recall exceeded aural recall, it was proposed that the nature of the task contributed in some way to the establishment of the visual items as more salient stimuli. Whereas no temporal or spatial component affected the definition of the nominal stimulus, the visual items may have been easier to recall and served as functional stimuli. In terms of a two-stage model of PA learning, the auditory stimulus would be processed as the response. Differences in performance on the two groups in this type of PA task were thus likely to appear at the associative stage.

There is, however, some evidence to suggest that the emergence of an identifiable population of visual attenders may be difficult in younger children. Day and Beach (1950) for example proposed that visual preference increases proportionately with the ability of the learner and the age of the learner. Children generally fail to show a visual dominance until the age of about 16. More recent attempts to relate modality preferences to reading achievement have not been overly successful (see Jones, 1972). Furthermore, in addition to the two modality preference groups identified in the Ingersoll and Di Vesta (1972, 1974) studies two additional groups were essentially ignored. Under conditions of bisensory presentation auditory and visual attending preferences were defined by the difference in magnitude of recall in auditory and visual stimuli in a bisensory digit-span task. Visual attenders were identified as those individuals who display preferred recall for materials presented visually while auditory-attenders were identified as those individuals who displayed preferred recall for materials presented auditorily. There were, however, individuals for whom no preference could be discerned. Of these some were able to process both channels equally well while others processed both channels

equally poorly. The relationship of the performance of these two groups of individuals to other bisensory behavior is essentially unanswered.

The purpose of the present study is to test conjectures about the relationship of attending preferences identified through the use of a bisensory short term memory task to the establishment of intersensory associations when either the auditory or the visual item is defined as the functional stimulus. Specifically, four groups of attenders are to be identified through high or low error rates on auditory and visual recall of a bisensory digit span. Differential performance is expected between these groups on the establishment of intersensory associations.

METHODS

Children's recall of auditory and visual items from bisensory digit-spans of the type described by Broadbent (1956; Broadbent and Gregory, 1961), Dornbush (1968)and Ingersoll and Di Vesta,(1972; 1974) were used to predict performance on a second, and independent, bisensory paired-associate task. Patterns of recall of auditory and visual digits were used to determine whether S had any apparent processing strategy that was imposed on the task. Attending preferences were defined by S's performance during the recall portion of 16 criterion trials. Four groups were selected on the basis of error rates in recall of auditory and visual stimuli in the bisensory digit spans. Ss were assigned to either High Auditory Error (HAE) Groups or Low Auditory Error (LAE) Groups on the basis of whether their performance fell in the upper or lower ranges of the error rate distribution for auditory recall. Similarly, Ss were assigned to High Visual Error (HVE) Groups or Low Visual Error (LVE) Groups on the basis of whether their performance fell in the upper or lower ranges of the error rate distribution for visual recall. By crossing these two factors in the selection of Ss, four groups of learners were identified: LAE/LVE, LAE/HVE, HAE/LVE, HAE/HVE.

The second task was a bisensory modification of a study-recall paired associate (PA) procedure. The procedures for a bisensory PA task differ from the traditional PA task since both halves of a given pair are presented simultaneously, one part on each of the two modalities, i.e., one word is presented visually while its associate is presented simultaneously auditorily. In this case, neither stimulus can be defined temporally or spatially as the nominal stimulus or response. During the recall portion of each of eight trials, half of the pairs had the visual member (Condition V-[ ]) defined as the nominal stimulus and half of the pairs had the auditory member (Condition A-[ ]) defined as the nominal stimulus. All learners were given eight trials to learn an eight pair list. Since all Ss received all pairs and since half of the pairs were identified as having the visual member serve as the nominal stimulus (V-[ ]) and half defined as having the auditory member serve as nominal stimulus (A-[ ]), the design was a mixed analysis of variance. The general design was a factorial design where attending preferences for males and females served as between-subjects dimensions while responses to auditory and visual nominal stimuli over eight learning trials served as 2 x 8 within-subjects dimensions.

Materials

The integers 1 through 0 (pronounced "zero") were used as stimuli for the digit-spans used in the attending preference task. Integers are randomly assigned to pairs of three-digit digit-spans with the restriction that a number could not occur twice within a given bisensory trial. Thus, any given number could not occur twice within a single digit-span nor could it occur in the digit-span presented simultaneously to the other channel. In all 19 digit-span sets were used in the modality preference task. The first three sets are to be used for practice trials. Those digit spans are found in Table 1.

Insert Table 1 about here

The stimuli for the bisensory PA task were all monosyllabic words, randomly selected, without replacement, from a pool of 400 words found in the Thorndike-Lorge (1944) 1000 most common words. Homophones (e.g., son or sun) were eliminated from the pool to minimize confusion errors due to response ambiguity during auditory presentation. Proper nouns and numbers were also eliminated from the pool. In all 16 words were selected and randomly assigned to eight pairs shown in Table 2. Care was taken to insure that verbal associates did not constitute a pair.

Insert Table 2 about here

When presenting a visual stimulus array (e.g., a digit-span) the members of the array can be presented at once (simultaneously) or the members of the array can be presented one at a time (sequentially). Stimulus members of an auditory array can only occur sequentially. Thus, to maintain parallel modes of presentation, both auditory and visual presentations of stimulus arrays were sequential.

The visual and auditory stimuli were presented on a 21 inch diagonal screen television monitor via a 1/4 inch AKAI videodeck (Model AKI000). Visual stimuli were dark images on a light field and auditory stimuli were recorded by a male experimenter. Digits were presented every two seconds. The exposure intervals were approximately .8 seconds for visual stimuli and an average exposure of approximately .85 seconds for auditory stimuli.

Table 1

Digit Spans Used in the Children's Version of the Attending Preference Task

	Visual	Auditory
	7-5-2	1-6-9**
	9-8-4	3-7-5**
	3-2-8	1-5-4**
1.	0-2-7	1-6-8
2.	1-0-5	2-6-8
3	4-1-3	7-0-6
4.	4-8-9	3-0-2
5.	9-8-3	2-5-0
6.	5-7-6	4-9-1
7.	1-0-3	5-9-8
8.	4-7-5	6-9-3
9.	6-1-9	7-5-0
10.	5-1-4	3-7-2
11.	9-0-7	2-6-8
12.	3-8-6	0-7-1
13	9-6-3	4-8-5
14.	2-9-5	3-6-8
15.	6-1-0	4-5-3
16.	3-4-0	9-8-6

**Practice trials

Table 2

Word Pairs Used in
Bisensory Paired Associate Task

Visual	Auditory
FLOW	DOOR
GLAD	VIEW
GROW	LADY
NEXT	WING
CART	SALT
CITY	SPOT
CAME	NICE
STOP	FINE

Subjects

Fifth- and Sixth-grade children from Bedford, Indiana served as subjects in this investigation. In all, 81 Ss were used in this experiment. Of the Ss, 39 were girls and 42 were boys. At the end of the academic year, the mean grade level performance of the children in this school on the reading subtest of the Iowa Tests of Basic Skills (ITBS, 1970) was 6.1 for the entire fifth grade and 7.2 for the sixth grade.

Procedure

A bisensory digit-span task and a bisensory PA task were presented successively. Upon arrival at the laboratory Ss were seated in front of a television monitor upon which was projected a pattern. S was then instructed as to the nature of the bisensory digit-span task. Ss were given three practice trials to determine whether they understood the instructions after which they were given 16 bisensory trials in which they were simply told to recall the numbers in the manner in which they felt most comfortable. However, S was told that he should try to recall the digits in order. Performance on these 16 trials served as a measure of attending preferences which was defined in part by the magnitude of the error rates in recall of the auditory and visual stimuli. Responses were scored not only for correct retrieval of the units but also for retrieval of the correct emporal position, i.e., the inversion of two digits during recall would constitute an error.

Following the bisensory digit-span task, the learner was given instructions describing the bisensory PA task. A study-recall procedure was employed. In that procedure a list is alternately presented for study and recall trials. During the recall phase Ss were given a response sheet on which for one half of the items the auditory item was presented and the learner was required to provide its visual correspondent (A-[ ]). The other half of the items presented the visual item and required the learner to provide its auditory correspondent (V-[ ]). S wrote all response to either the auditory or visual stimuli during the recall trials. Each S was given eight study and eight recall trials in which he was instructed to complete as many of the eight pairs as possible.

RESULTS

The purpose of this experiment was to test conjectures about possible differential performance of children who display attending preferences during and bisensory digit span recall on the acquisition of intersensory associations under conditions of a bisensory paired associate task. Specifically, learners who show different error rates in recall of auditory and visual stimuli during recall of bisensory digit spans were compared on their ability to establish intersensory associations when either the auditory or visual item in an intersensory pair served as the nominal stimulus. Presented below are analyses of variance intended to explore that relationship.

Attending preferences were defined by recall performance on a bisensory digit span task. LAE and HAE auditory groups were identified by a median split in the error distribution of the sample. Similarly, LVE and HVE visual groups were identified by a comparable median split on the distribution of visual error scores for the sample. The median error rate for the visual errors was approximately eight while the median for auditory errors was two. As in previous research, the distribution of recall patterns under auditory presentation is much more skewed than for visual presentation. Overall, a comparison of error rates for the Ss yielded $t = 7.59$, $df = 80$, $p < .01$, indicating an overall superiority of recall for the auditory items. Since the median auditory error rate was so low, comparisons of LAE and HAE groups in conjunction with visual error output was deemed useless. To do so would only create contamination of the data since it was not possible to reasonably generate the four attending groups originally defined without having coterminous boundries of LAE and HAE groups. No group (e.g., HAE/LVE) was thus identified to parallel earlier (Ingersoll & Di Vesta, 1972, 1974) visual-attenders.

Analyses of Variance

The first comparisons used a completely within-subjects analyses. Overall, acquisition under the V-[ ] condition was significantly superior to acquisition under the A-[ ] condition, $F(1, 80) = 7.39$, $p < .01$. Additionally, a test of change of performance over trials yielded $F(7, 560) = 31.66$, $p < .001$, indicating that the children were indeed attending to the PA task and that the task was not so difficult as to suppress acquisition.

As stated above, partitioning Ss into LAE and HAE was deemed inappropriate due to potential sources of contamination of groups. Ss were thus partitioned only into LVE and HVE groups. An equal number

(n = 10) of boys and girls were selected from the extremes of the visual error distribution. The analysis used a mixed design with visual error groups and sex serving as the 2 x 2 orthogonal between-subjects dimensions and acquisition under A-[ ] and V-[ ] nominal stimulus conditions over eight trials as the 2 x 8 within-subjects dimensions. The results of that analysis are summarized in Table 3.

Insert Table 3 about here.

The sex by visual error group interaction, although not statistically significant ($.05 < p < .10$), may be useful for heuristic purposes. A comparison with a Scheffe test of performance of the two groups of girls yielded $S^2 = 3.61$, $p < .10$ with the mean performance of LVE girls ($\bar{X} = .75$) exceding that of HVE girls ($\bar{X} = .45$). While the reverse seems to be indicated in the performance of boys, i.e., the HVE boys ($\bar{X} = .84$) outperform the LVE boys ($\bar{X} = .60$), that difference is not statistically significant.

More important is the three-way interaction between visual error groups, stimulus probe, and learning trials which yielded $F(7, 252) = 2.59$, $p < .05$. The nature of that interaction can be discerned from Figure 1. As will be noted in that figure, the differences in the performance of the LVE and HVE Groups under A-[ ] and V-[ ] conditions appear to be found in the last four learning trials. A comparison of the mean performance of the LVE ($\bar{X} = .64$) and HVE ($\bar{X} = .81$) Groups on those trials under the A-[ ] condition yielded $F(1, 252) = 3.06$ which is significant at the $p < .10$ level. In contrast, a comparison of mean performance on those same trials for the LVE ($\bar{X} = 1.19$) and HVE ($\bar{X} = .96$) under the V-[ ] condition yielded $F(1, 252) = 5.06$, $p < .05$.

Insert Figure 1 about here

Visual Errors and Reading Achievement

Additional analyses were conducted on the data to explore possible relationships between visual error performance and reading achievement as reflected in performance on the reading subtest of the Iowa Tests of Basic Skills. The results of the analysis indicate that the mean reading grade level of the LVE Group ($\bar{X} = 7.6$) exceded the mean reading grade

level of the HVE Group ($\bar{X}$ = 6.6). Further, the differences between the two groups was statistically significant, t = 1.97, df = 38, $p < .05$. Relating visual errors during bisensory recall for the entire sample to reading achievement with the effects of grade level statistically partialled out yielded $r_{xy.z} = .18$, p = .11. While that correlation fails to be statistically significant, it is clearly in the expected direction.

Table 3

Analysis of Variance Summary Table for Correct Responses on a Bisensory Paired-Associate Task as a Function of Prior Visual Recall and Sex of Subject

Source	df	MS	F	p<
Between-Subjects				
Visual Performance (V)	1	.16		
Sex (S)	1	2.26		
V X S	1	11.56	3.69	.10
error (b)	36	3.13		
Within-Subjects				
Trials (T)	7	6.91	20.32	.001
V X T	7	.08		
S X T	7	.21		
V X S X T	7	.41		
error (W_1)	252	.34		
Stimulus Probe (P)	1	12.10	7.91	.01
V X P	1	.63		
S X P	1	1.63		
V X S X P	1	.63		
error (W_2)	36	1.53		
T X P	7	.36		
V X T X P	7	1.02	2.59	.05
S X T X P	7	.33		
V X S X T X P	7	.54		
error (W_3)	252	.40		

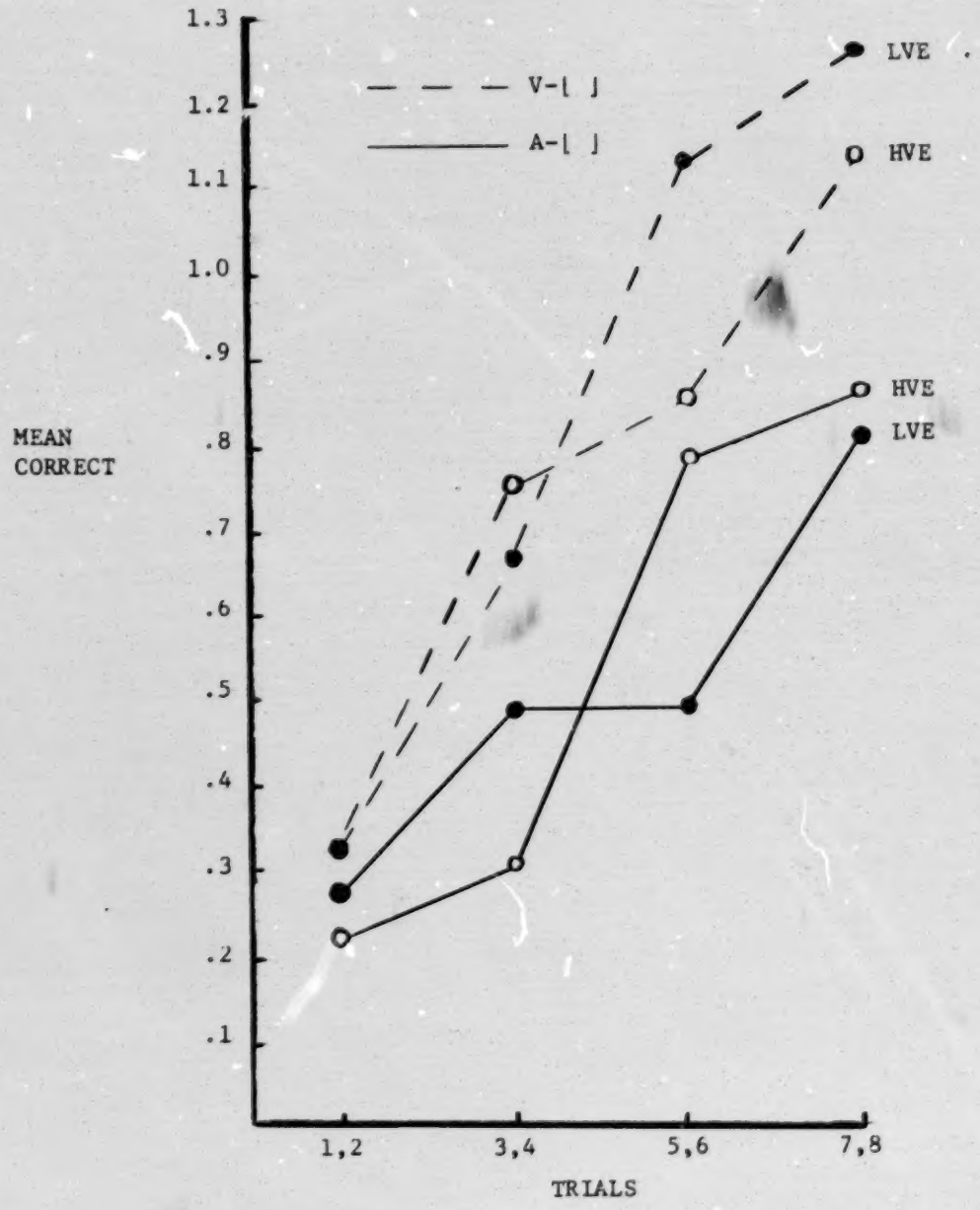

Figure 1: Paired Associate Performance of LVE and HVE Groups Under A-[ ] and V-[ ] Conditions

DISCUSSION

If the results of this study were to be described as less than equivocal, this discussion would be misleading. It is clear, given these results, that the performance of children at the fifth and sixth grades is not parallel to the populations studied in earlier investigations. While in previous studies distinct groups of aural attenders and visual attenders were identified, the data found in this study failed to yield that differentiation. Perhaps an increase in the difficulty of the task would lead to greater variance on auditory recall. Indeed, differentiation on the basis of auditory errors during recall was insufficient to be used in the separation of the groups. In essence, both groups identified were low auditory error groups. The use of a LAE/HVE groups is probably approximate to the aural attender identified within an adult population. However, no comparable group to the adult visual attenders was found.

In part, the results of this study clarify some of the results found in the Ingersoll and Di Vesta (1974) study. In that study the authors conjectured that the salience of the visual items during original presentation might have been great enough for those visual items to serve as functional stimuli although, in that case, no nominal stimuli had been identified. Further, the authors concluded that aural attenders held an advantage during response integration of the auditory stimulus. The results were in accord with that model. The results of this study suggest, however, that that interpretation may in part be misleading. At least within the context of this task, the V-[ ] associations are simply easier to learn than the A-[ ] associations. Further, the groups that showed the least modality dominance, the LVE group, performed better than the HVE group which was presumed to parallel the aural attenders found in the adult population. It is clear, however, that attending preferences are differentially related to acquisition of intersensory associations. The HVE group was at a disadvantage during V-[ ] acquisition but not during A-[ ] acquisition. Since the HVE group would have more difficulty integrating the visual item than the auditory item, effects of the interference show up in difficulty in establishing visual items as functional stimuli with which to integrate auditory responses.

The data support a limited capacity model. In settings where information is arriving on more than one channel, individuals differentially sort out or select one or the other of the modalities and that modality which they select is a stable response characteristic. Thus, we might

assume that in areas where audio-visual correspondents are necessary some information may be lost because of the nature of multichannel stimulation. This loss may be augmented by selective attending factors employed by each type of individual. Students who consistently fail to attend to the visual component of the task will suffer most when the task demands are made for establishing intersensory associations when the visual item serves as the functional stimulus and the response is processed from the auditory channel. It would appear, then, that in settings of auditory-visual concomitance more research is needed to delimit the effects of both attending preferences and modality effects under bisensory stimulation.

It has been suggested by Neisser (1967) that visual information is stored in an ikonic form that is stable through perceptual transformations. If an auditory stimulus is associated with a graphic stimulus the stability of that intersensory association over transformations should be related to the adequacy of the original storage. Once an association between an ikon and its auditory associate is well established, the learner should be able to retrieve that association although the graphic stimulus has been modified. On the other hand, if the storage of the original ikonic image is less stable, there is a concomitant increase in the probability that errors would enter into associative behavior of the learner under conditions of transfer, or transformations of the original stimulus. Further, the storage of the visual stimuli and their auditory associates is very likely filtered through each individual's processing preferences reflected, e.g., in attending patterns during bisensory stimulation. Thus, it would be predicted that the storage of visual items available as functional stimuli should be linearly related to visual error rate during recall of bisensory digit spans. Likewise, transfer of paired-associate recall on transformations of the visual stimulus should also be differentially related to the predispositions of these attending patterns. That question is currently investigation using a bisensory modification of the research paradigm developed by Gibson (1941). Drawing parallels, however, between the attending preferences or recall patterns shown in children and adult populations is hazardous and should be done with extreme caution without more research.

It is likely that beginning reading emphasizes the types of associations represented by the V-[ ] condition. That is, a visual array with

little intrinsic meaning is to be associated with an auditory correspondent that is assumed to already have a meaning attributed to it. By the fifth and sixth grades, the Ss have already had considerable experience with instruction in the V-[ ] mode. The overall superiority of the V-[ ] condition might thus be related to a difference in the frequency of exposure. The similar superiority found with adults may not have been due to differences in salience, but rather to differences in preferred mode of integration. While the reading acquisition process is not totally parallel to the V-[ ] component of the bisensory PA paradigm, there are strong similarities. Therefore there would be an expected inverse relationship between visual error performance and reading achievement. This is precisely what was found. The relationship between visual error rate is worth further investigation. While a low negative correlation was not statistically significant, it was clearly in line with the relationships found by other investigators (e.g., Birch & Belmont, 1965; Kahn & Birch, 1968; Muehl & Kremenick, 1966).

Some of the results of this task do not correspond to those found by Siegel & Allik (1973) who found no differences in recall as a function of the modality of the stimulus probe. Those investigators did find an interaction between presentation modality and recall cue for response latencies. An overall longer latency for visual cuing for recall of auditory stimuli was found. While there are significant task differences in these two investigations, and these task differences might account for some of this discrepancy, they cannot account for all the differences. Clearly, further investigation in this area is needed to unravel these differences.

Summary

In summary, the results of this study are supportive of a model of information processing that suggests that learners impose control processes on the flow of information within the organism. It is not clear, however, what the nature of these control mechanisms are in children or adults. The nonsignficant but expected relationship between performance on the bisensory digit span task and reading achievement is clearly supportive of further research in the area as well as further research in the area of the relationship of attending patterns to the establishment of intersensory associations.

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